LBNE Beam and Detector Performance

DOE Site Visit Breakout Session Discussion

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CP Violation, Mass Hierarchy and $\nu_\mu \longrightarrow \nu_e$

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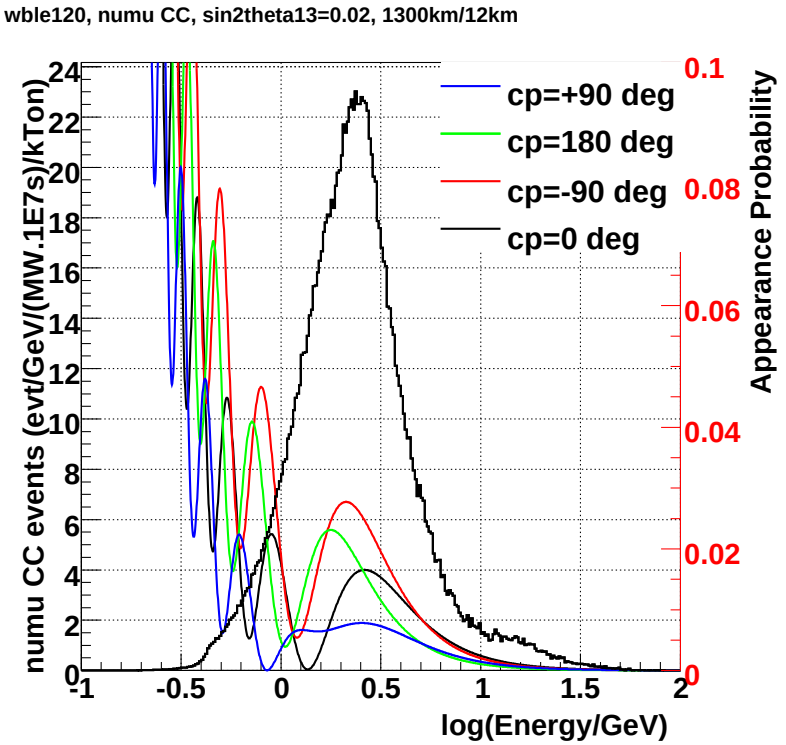
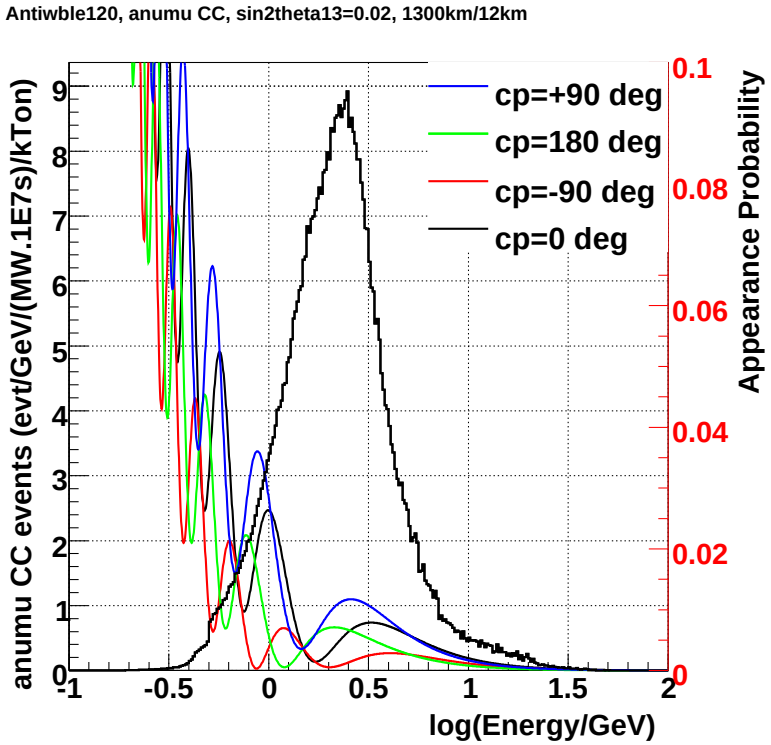
Appearance probabilities of $\nu_\mu \longrightarrow \nu_e$ for different values of the CP phase.
A CP phase $\neq 0, \pi$ implies CP is violated in the lepton sector.

Normal Hierarchy

ν



$\bar{\nu}$



CP effects largest $E_\nu < 3$ GeV.

CP Violation, Mass Hierarchy and $\nu_\mu \longrightarrow \nu_e$

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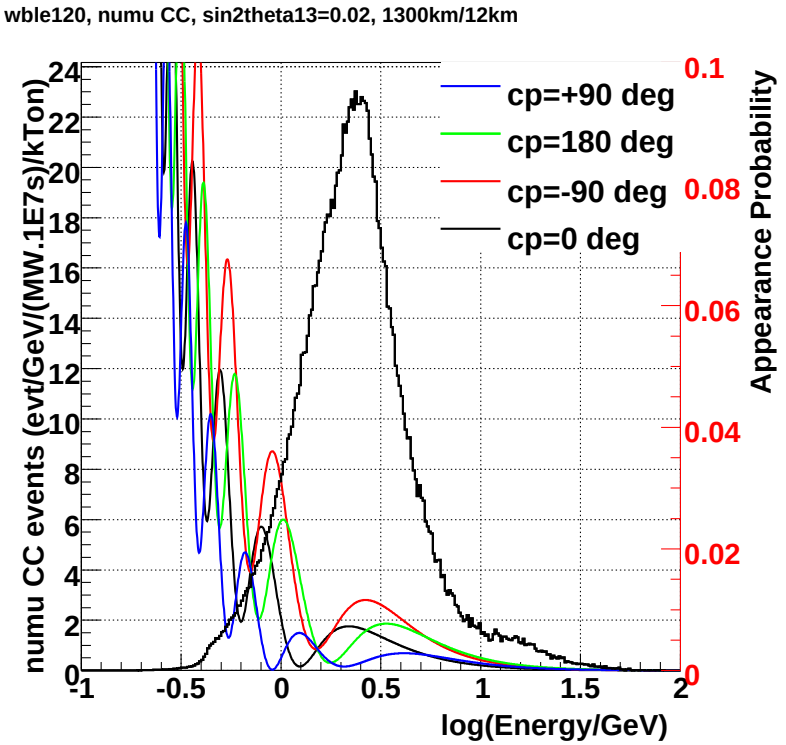
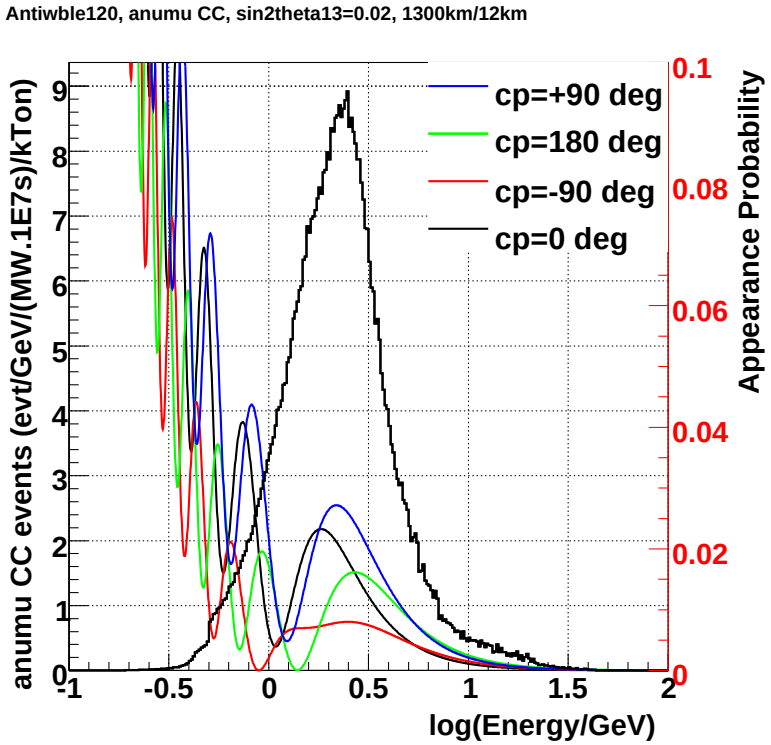
Appearance probabilities of $\nu_\mu \longrightarrow \nu_e$ for different values of the CP phase. A CP phase $\neq 0, \pi$ implies CP is violated in the lepton sector.

Reversed Hierarchy

ν



$\bar{\nu}$



Matter effects large $E_\nu > 1.5$ GeV.

LBNE Beam Simulations

LBNE Beam and Detector Performance

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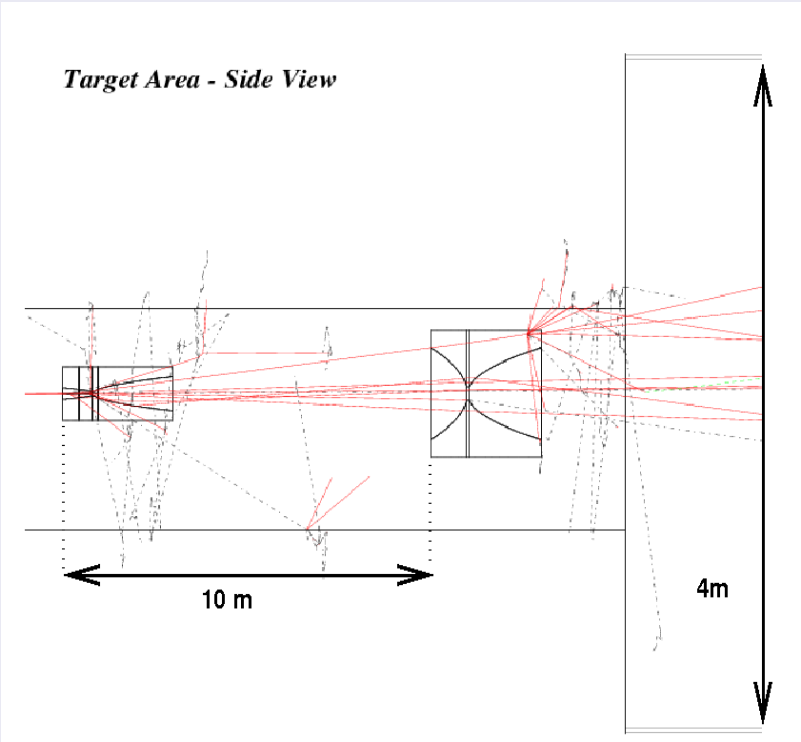
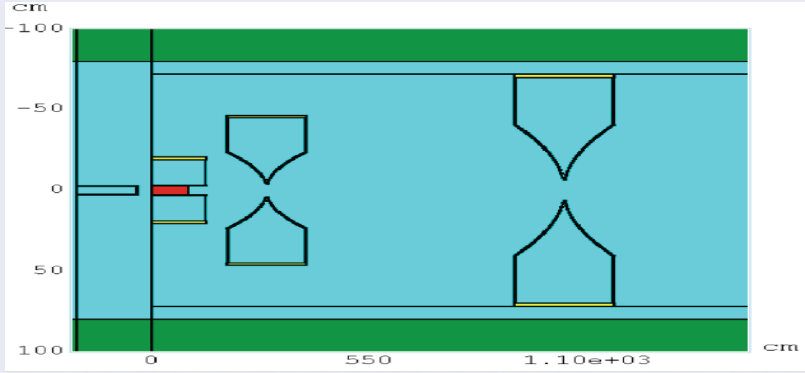
Two *INDEPENDANT* efforts on focusing system designs for CD1

M. Bishai, BNL (NuMI based)



B. Lundberg, FNAL (T2K based)



Both use embedded targets and focusing horns.

Un-optimized focusing/targeting based on horns only. Which is better for physics? What about solenoids (local BNL expertise on neutrino factories/muon colliders)?

Target and Horn Radiation Damage Tests

data from Nick Simos, BNL

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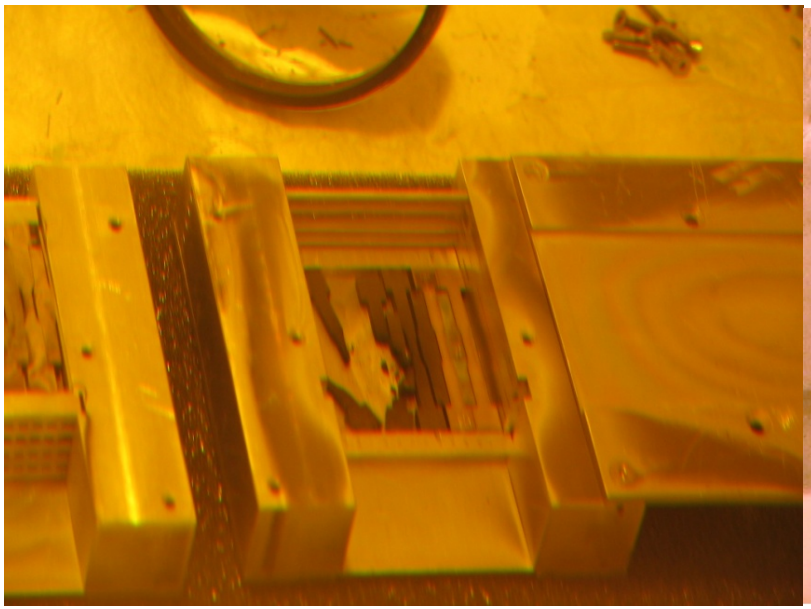
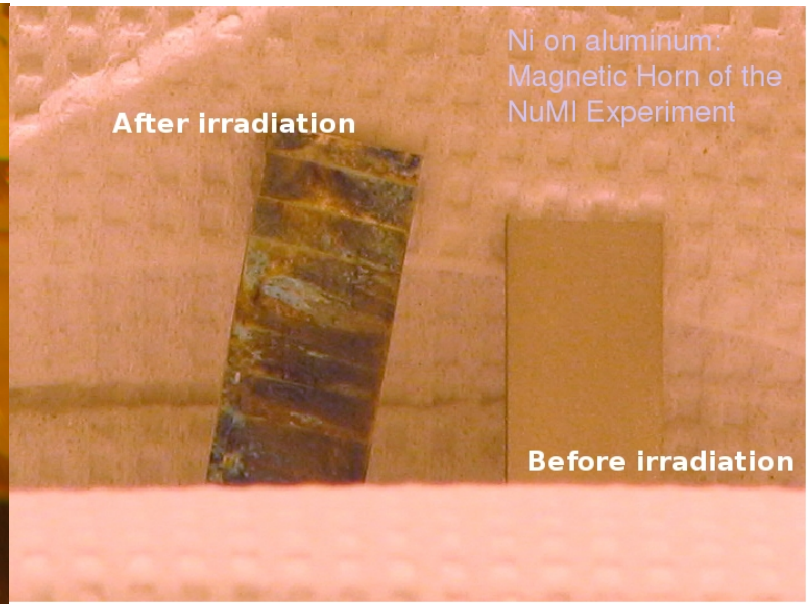
LBNE targets and horns have to withstand 2 MW beams for a decade!

200 MeV Proton fluence at BLIP (Brookhaven Linac Isotope Producer) $\sim 10^{21}$ p/cm^2 ($\sim$ 2 yrs with 300kW NuMI beam):



IG43 Graphite



NuMI Horn Materials

This work was carried out independant of the LBNE effort at BNL. **M. Bishai is requesting extra support for BNL efforts on target irradiation and material R&D for LBNE.**

LBNE Beam Design Considerations

LBNE Beam and Detector Performance

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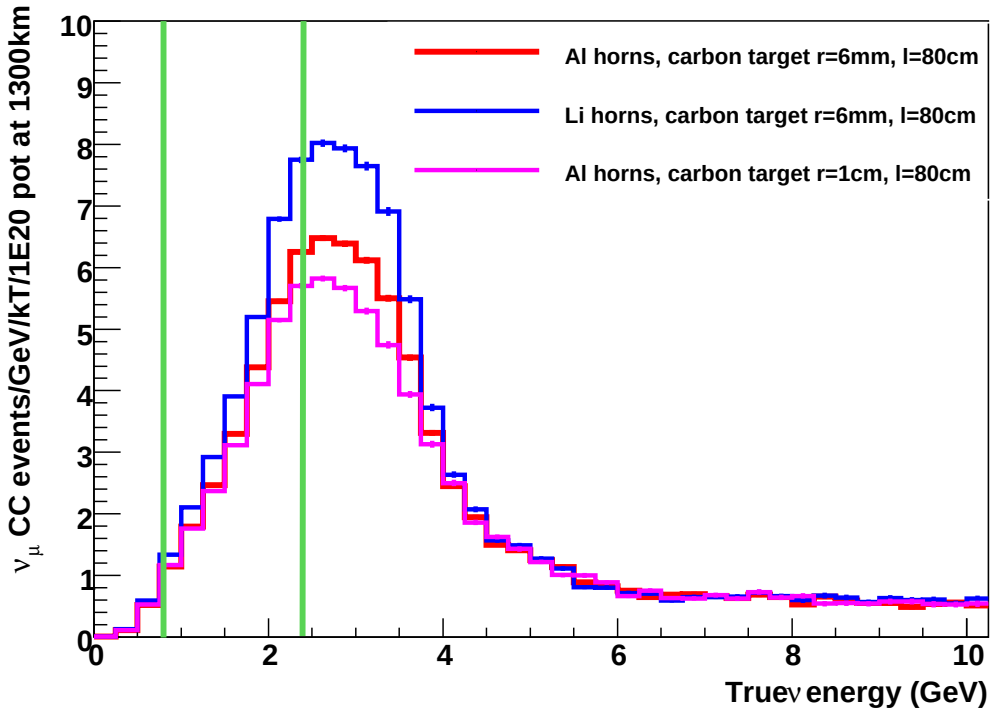
Using a NuMI-based LBNE design with a 120 GeV on-axis proton beam:



Selection of horn materials and target design has significant impact on the flux. Physics sensitivity has to be preserved in a realistic design
Starting with high energy proton beams (120 GeV) - its difficult to cover the region of the 2nd oscillation maxima and solar oscillation.

LBNE/DUSEL Detector Performance

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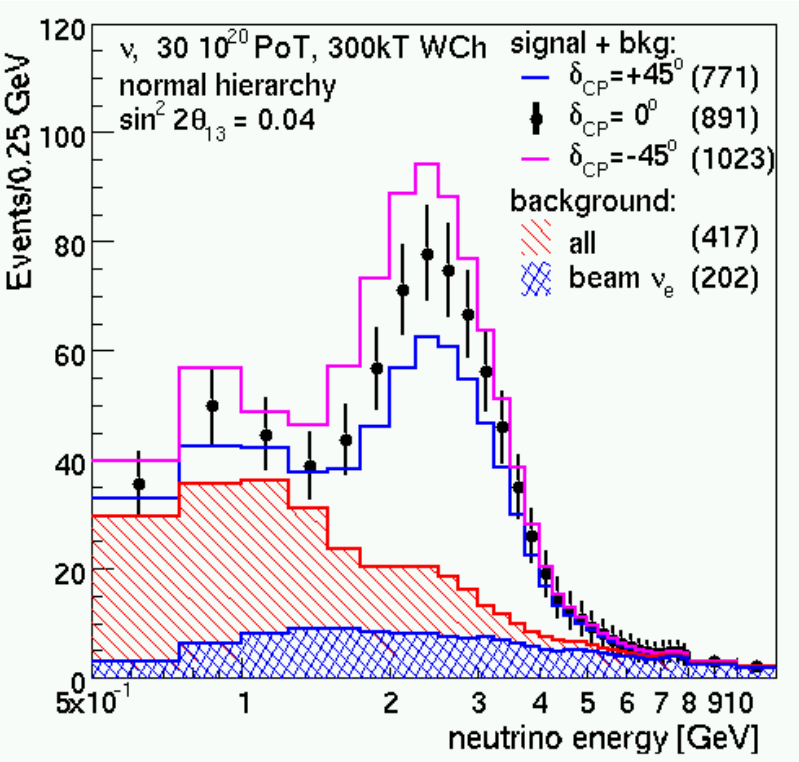
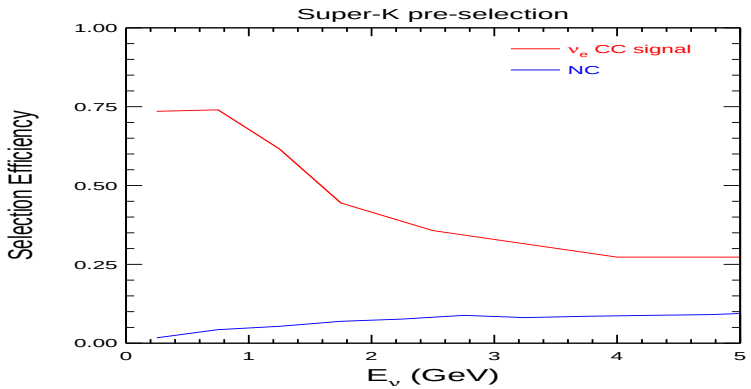
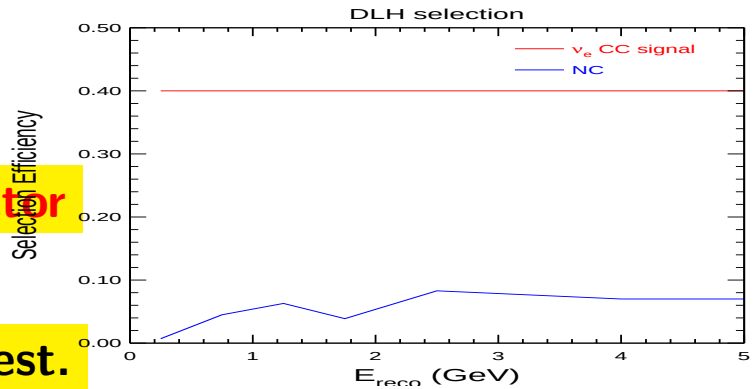
A preliminary on-axis wide-band beam for LBNE based on the NuMI focusing system has been developed. Current LBNE water Cerenkov response is based on SuperK MC using single e-like ring PID:



SuperK preselection efficiencies



SuperK DLH ν_e selection



Need to simulate actual LBNE detector

Signal eff. at 2.4 GeV is only 14%!

But that is where beam flux is greatest.

Improvements to detector response possible!

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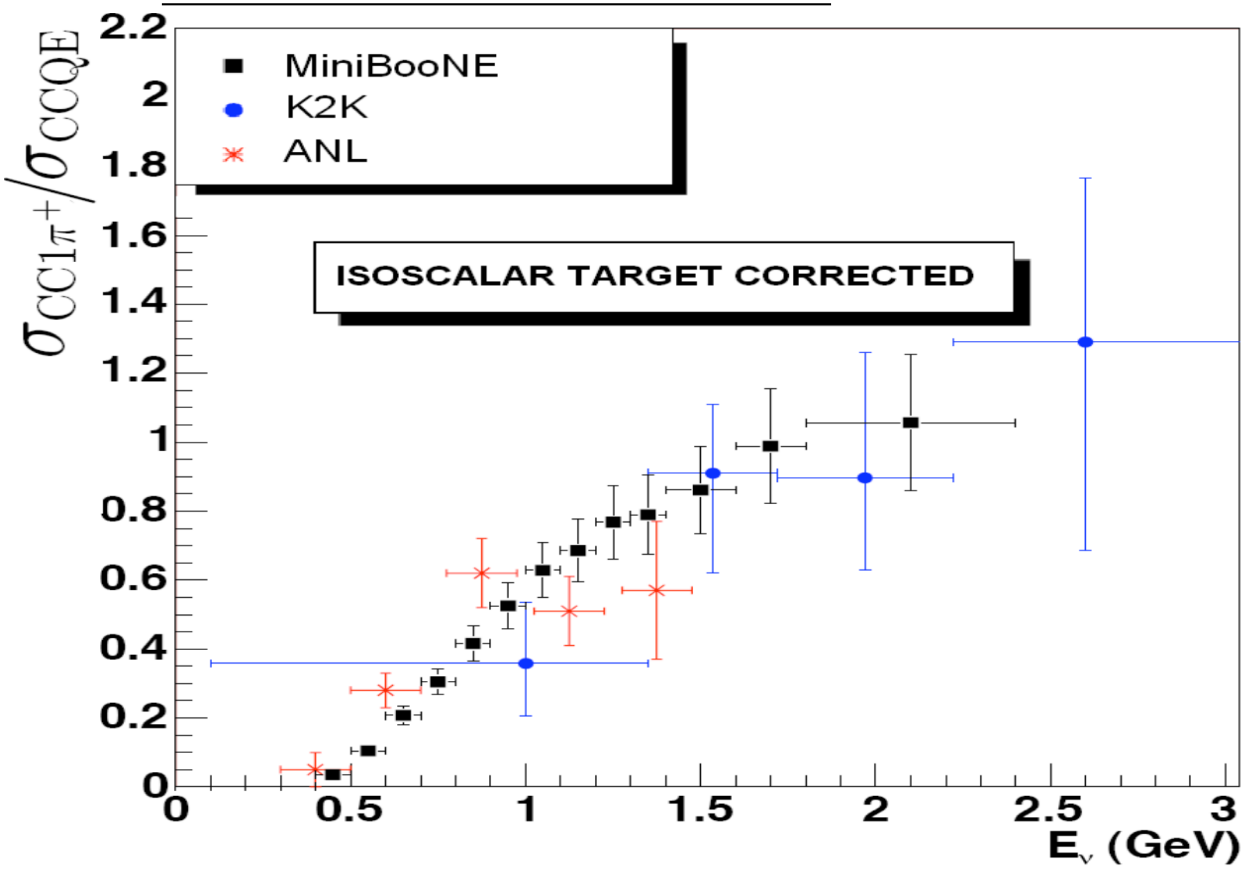
MiniBoone has measured the $\nu_\mu + \mathrm{N} \rightarrow \mathrm{N}' + \mu +$ single π cross-sections in a large Cherenkov detector arXiv:0904.3159v1:



Optimized reconstruction of multi-ring events will improve LBNE detector response to multi-GeV beam and improve physics sensitivity.

Optimization of LBNE sensitivities

LBNE Beam and Detector Performance

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Detector and beam simulation and reconstruction efforts are needed to optimize LBNE before beam and detector designs can be finalized. Photo-detector performance and designs of MW target/focusing systems impact ultimate beam and detector capabilities.

- **Improve low energy ν_e signal to background (π^0) discrimination.**
- **Improve multi-GeV ν reconstruction efficiency for both ν_μ disappearance, ν_e and ν_τ appearance.**
- **Increase beam coverage at low energies (large CP) using a variety of techniques: focusing system optimization, running with lower beam energies, running off-axis.**
- **Explore beam and detector options for new physics sensitivities: e.g. higher energy neutrinos could probe anomalous interactions.**
- **Targeting R&D is critical using BNL facilities and expertise. We need a target/horn system that can withstand $> 10^{22}$ p.o.t!**

Requesting support for 2 postdocs+student (?) and materials to optimize beam AND detector simultaneously. Work involves simulations and R&D efforts on beam targeting and photodetector technology. Builds on existing expertise in beam and detector simulations and R&D facilities.